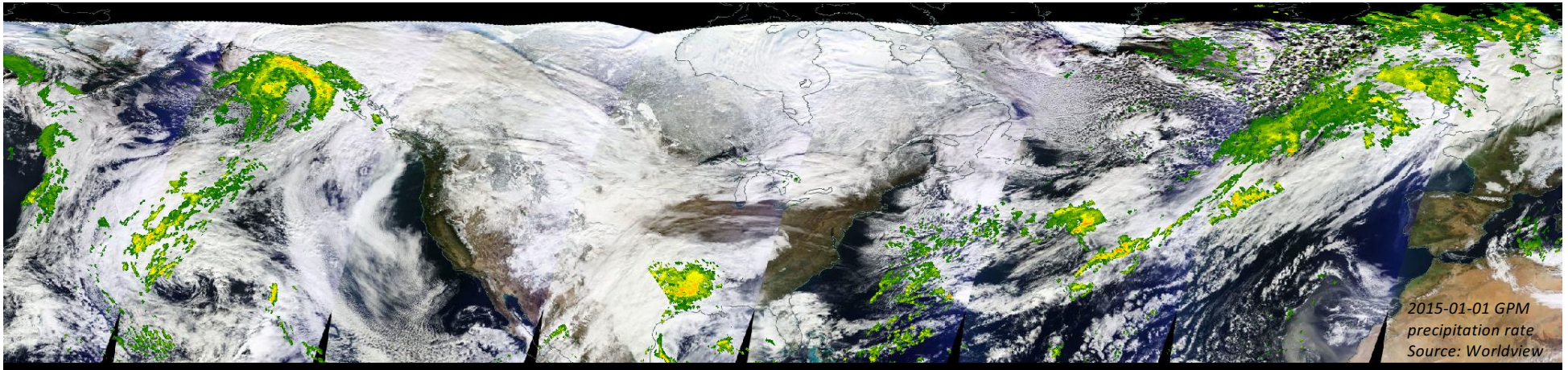


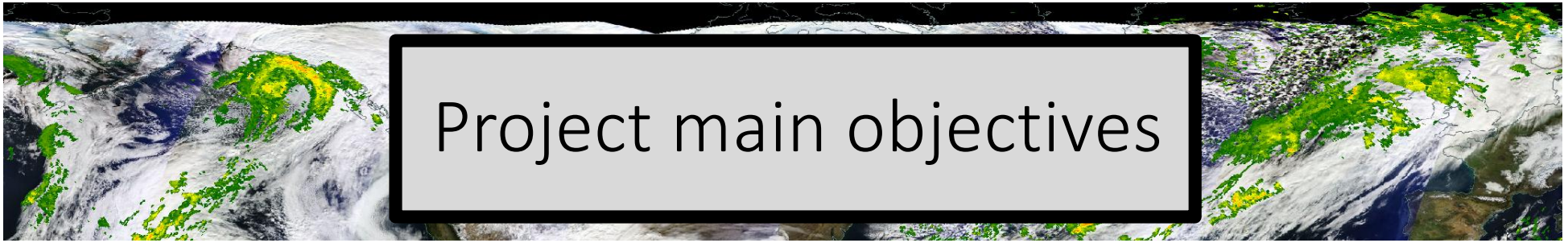
GPM Precipitation in Extratropical Cyclones

Catherine Naud, Columbia University/NASA-GISS

James Booth, CUNY-City College of New York

PMM Award # NNX16AD82G

PMM science team meeting, Houston TX Oct. 24-26 2016

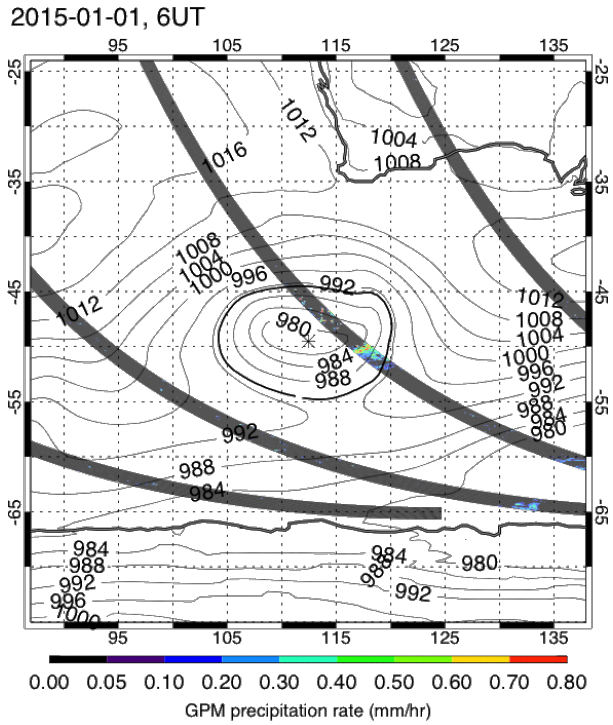


Project main objectives

- Background: Extratropical cyclones (ETC) = important purveyor of precipitation in midlatitudes but no consensus on evolution in warming climate, i.e. more or less precipitation?
  => model representation of precipitation processes in ETCs in question
- Project goals:
  1- construct database of GPM precipitation associated with ETCs= GPM-ETC
  2- use database to evaluate GCMs + MERRA-2
  3- use database to explore processes within cyclones associated with precipitation and precipitation extremes

Objective 1: Construct GPM-ETC database

- ETC locations and tracks: MCMS (Bauer et al., 2016), based on ERA-interim 6-hourly SLPs
- Keep ETCs with center within 30-60N/S, land and ocean, from March 2014 onward
- For each 6-hr cyclone location, collect **L2 CMB DPR+GMI** V4 files that are within ±3 hours and 25^{o} from cyclone center
  => includes ~ 2/3 of all cyclones per month
- Save one file per cyclone with following information:
  - Description of low pressure center (lat.,lon., SLP, surface)
  - ETC *track* information (i.e. info for all 6-hrly positions during ETC life)
  - Name of all CMB files coincident in time and space
  - For all these CMB files: arrays of latitude, longitude, precipitation rate, type, and liquid fractions and surface type along orbit
- When V4 available, also include **IMERG**
- *Available on demand through ftp server, contact* cn2140@columbia.edu *or* jbooth@ccny.cuny.edu

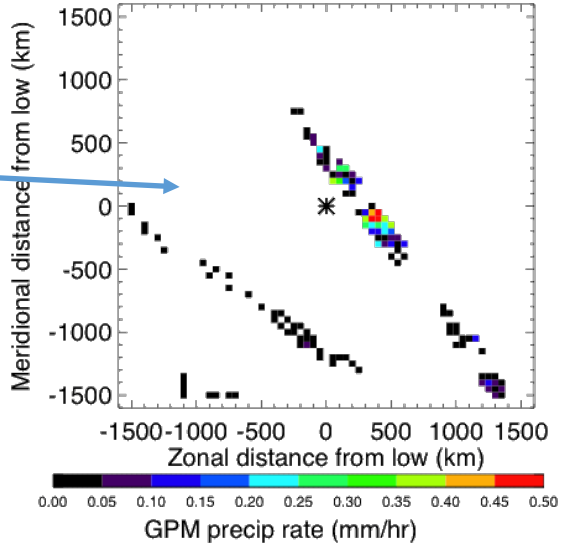


Southern Ocean cyclone: 2015-01-01, 06 UT
Latitude= 49.53^{o}S Longitude=112.43^{o}E
Contours= MERRA-2 SLP
Dark bands: 4 GPM orbits
Colored pixels: Ka+Ku+GMI precipitation rate
Orbits start time: 03:02UT, 04:34UT, 06:07UT and 07:39UT
Note -65^{o}S limit for orbits

Objective 2: Models evaluation

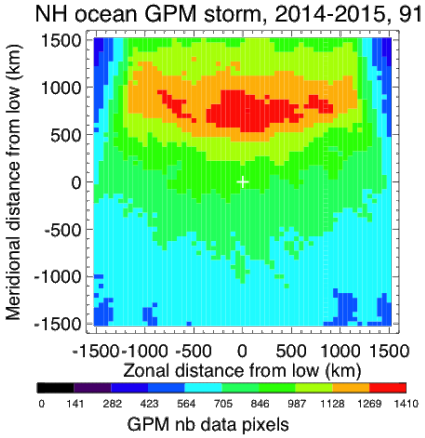
First compare CMB precipitation against MERRA-2
=> can collocate, avoid some sampling issues
Problem with CMB: Narrow swath= non-uniform coverage of cyclone

⇒ Project data onto equal area grid centered on the low
⇒ Resolution of 50 km to match MERRA-2
⇒ **Composite** by averaging together a large number of cyclones
⇒ For MERRA-2 use minimum precipitation rate =10^{-4} mm/hr to match GPM
⇒ Example for all **NH ocean cyclones** in 2014-2015 (Mar.-Dec.): 9148 cyclones

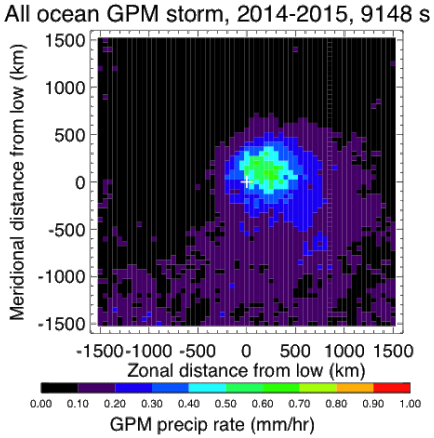


Projected in 50 km x 50 km pixel grid centered on low
Southern Ocean cyclone:
2015-01-01, 06 UT
Latitude= 49.53°S
Longitude=112.43°E

Number of pixels per 50 km box

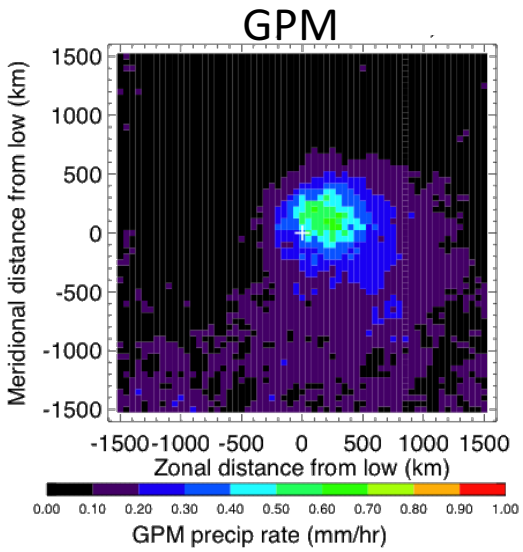


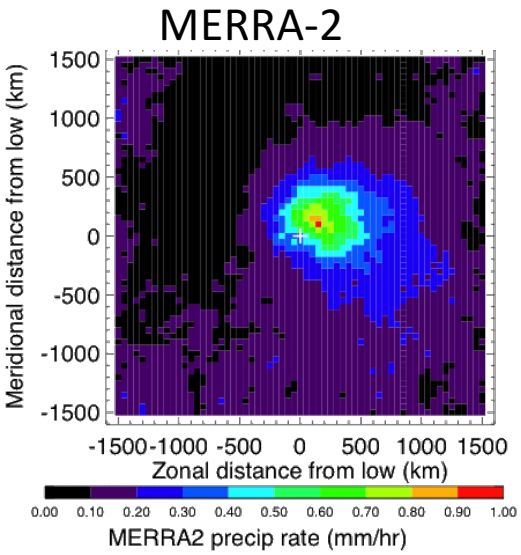
CMB precipitation rate



Comparison MERRA-2 vs GPM: using collocated pixels

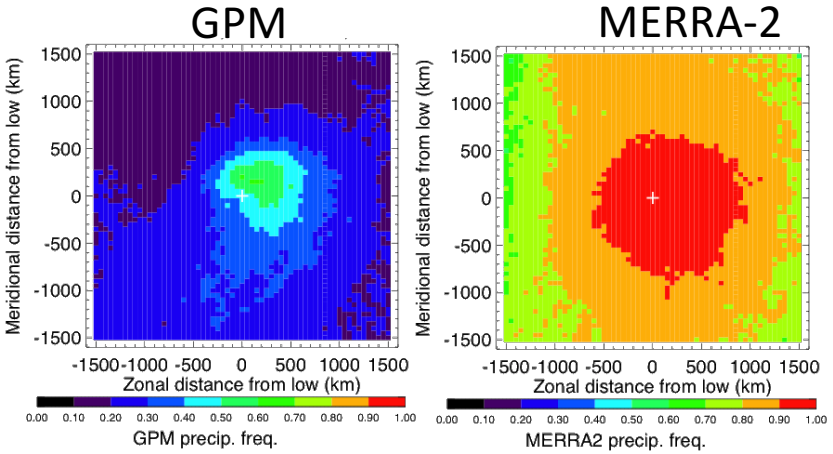
GPM
precipitation rate
=> MERRA-2 rates greater than GPM



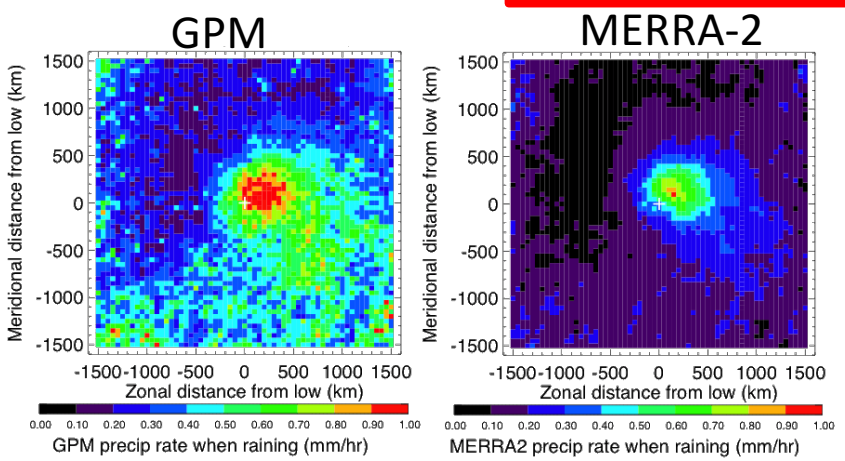


MERRA-2
precipitation rate: same cyclones as GPM and same pixels

MERRA-2 displays differences with GPM similar to other models: precipitation more frequent and weaker



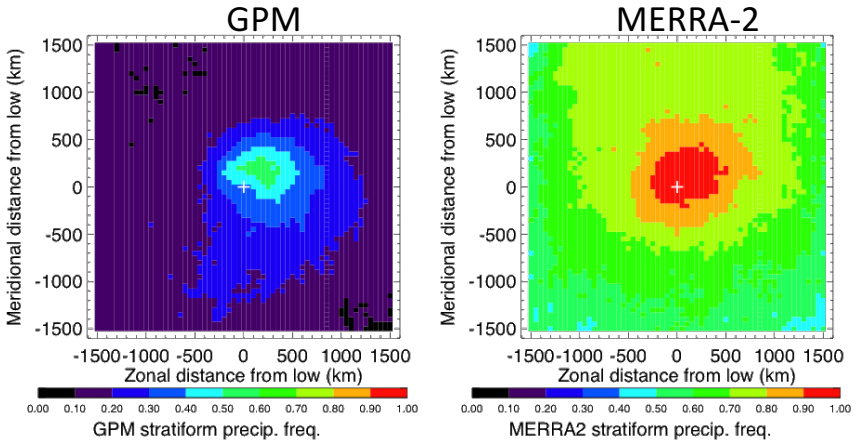
Frequency of occurrence: GPM vs MERRA-2



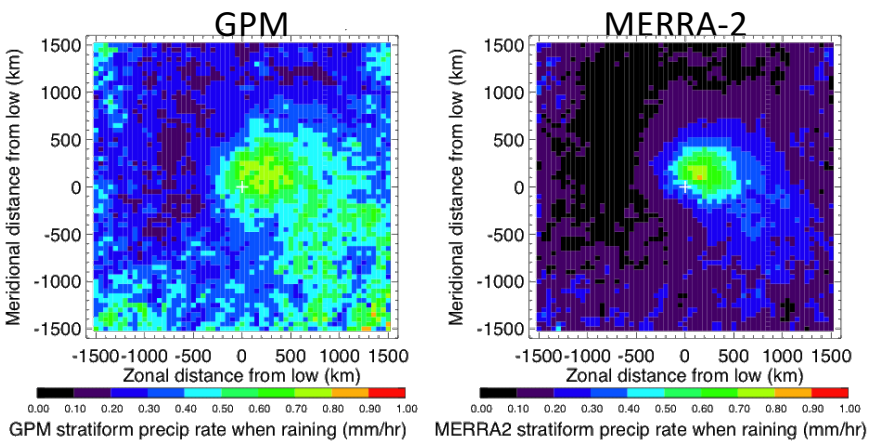
Rain rate when raining: GPM vs MERRA-2

Comparison MERRA-2 vs GPM: Large scale & convective precipitation

Freq. occurrence of large-scale rain



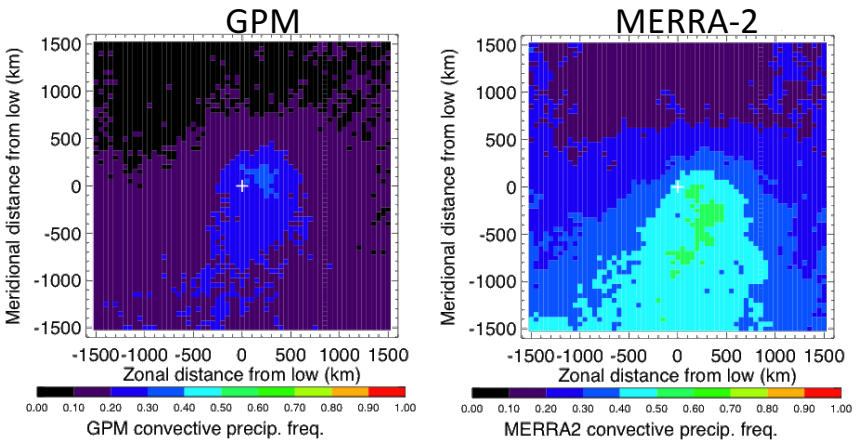
Rain rate when large scale rain



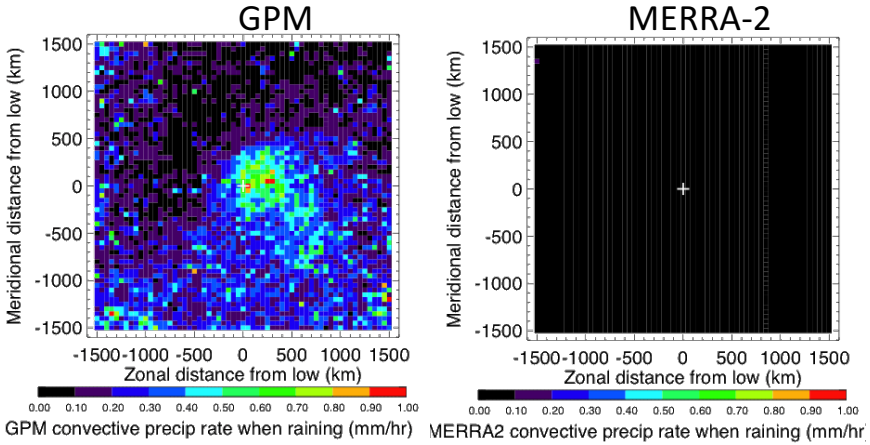
⇒ Large-scale (stratiform) rain (above): MERRA-2 overpredicts occurrence of large scale precipitation but rain rate ok close to the low, while too small everywhere else

⇒ Convective rain (below): too frequent in MERRA-2 but in the right place, while rate significantly weaker than observed

Freq. occurrence of convective rain



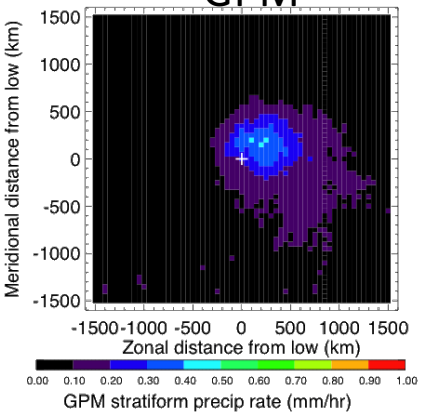
Rain rate when convective rain



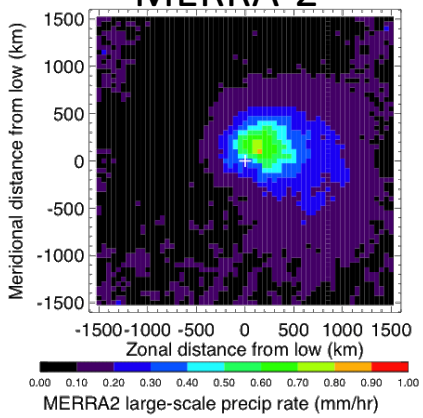
Rain type: potential discrepancies in definition

Mean precipitation rate: **large-scale**

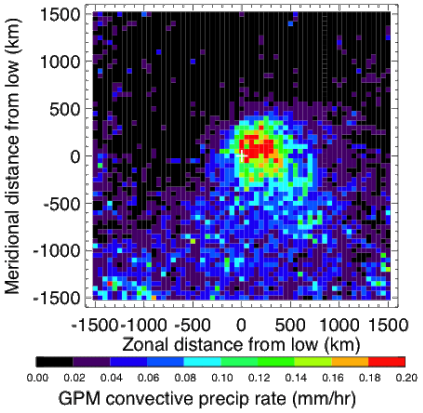
GPM

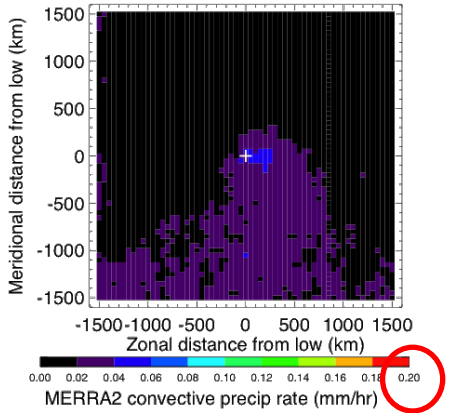


MERRA-2



Mean precipitation rate: **convection**





1) MERRA-2 large-scale precipitation much larger than GPM, because of greater occurrence despite lower rates: Radar low sensitivity to drizzle might be reason for large-scale GPM-MERRA2 differences?

2) MERRA-2 convective precipitation much lower than GPM because of rain rate: precision issue?

Other potential issues:

-MERRA-2 type “anvil”: not included but frequent

- Fundamental differences with GPM typing?

- Next: explore convection in ETCs with GPM vs. NexRAD

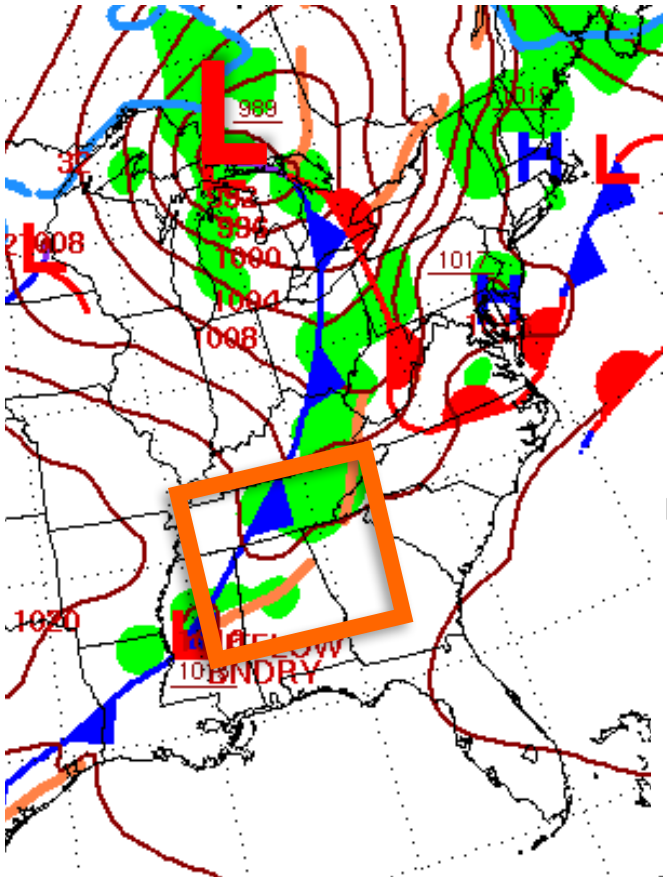
Objective 3: Convection in ETCs

Jimmy Booth,
JJ Jeyaratnam,
Johnny Luo

Convection vs stratiform rain in NEXRAD and GPM: establish importance of convection in strong events

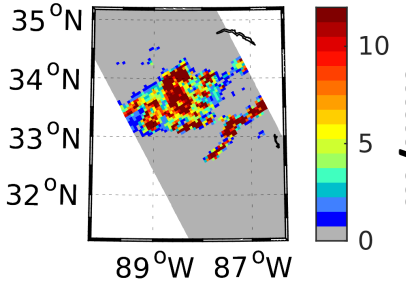
1. Identify strong rain events in **L2 CMB DPR+GMI**
2. Focus on NE US and obtain coincident NEXRAD
3. Isolate convective cores in GPM and NEXRAD (two techniques)

We do not want to re-invent the wheel.
Our focus is on linking convection to ETCs

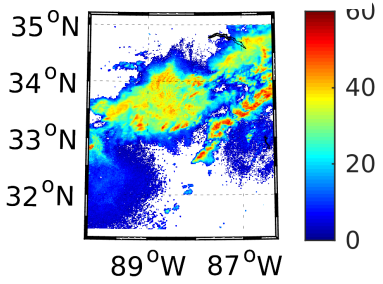


CASE STUDY ANALYSIS: April 10, 2015

GPM PRECIP RATE

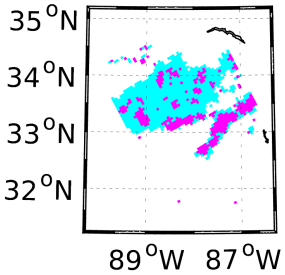


NEXRAD REFLECTIVITY at 2km (dBz)

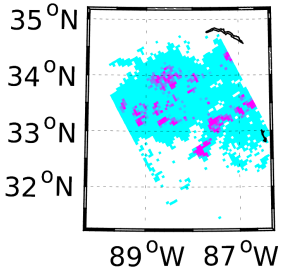


Convective (purple) and stratiform (blue) precipitation locations

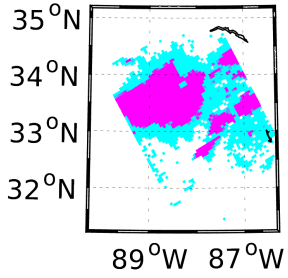
Precip Type from GPM



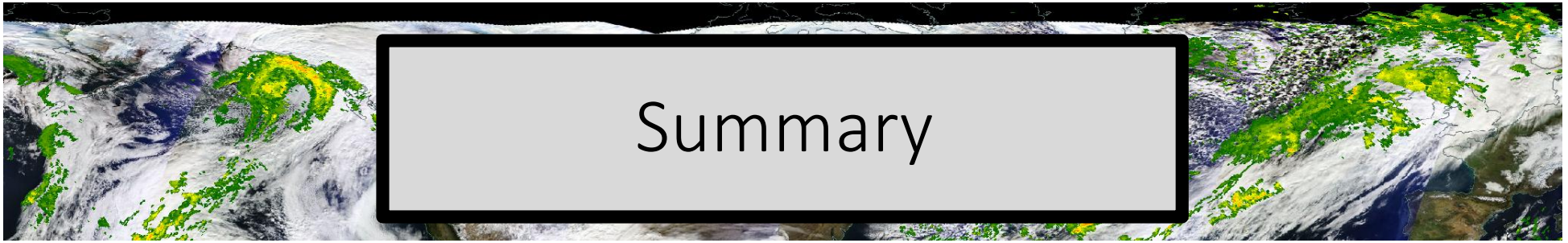
Core using vertical profile



Steiner* core selection



Great similarities between GPM and NEXRAD vertical-scan analysis



Summary

- GPM-ETC database:
  - CMB product: for each cyclone detected in the midlatitude, original CMB files content (latitude, longitude, precipitation rate, liquid fraction, type and original file names)
  - Available on ftp server for 2014-2015, email cn2140@columbia.edu or jbooth@ccny.cuny.edu for access information
  - Next: create same with IMERG V4
- MERRA-2 preliminary evaluation using CMB:
  - can compare collocated and coincident precipitation occurrences
  - useful also to establish strategy for comparison with GCMs
  - Some evidence that MERRA-2 might drizzle more often that can be measured with GPM-CMB + might underestimate convective rain rates.
  - more work needed to fully characterize potential uncertainties in CMB
  - use as benchmark to help in GCM evaluation
- GPM vs. NEXRAD preliminary result: convective core identification does well
  Future work - compare convective occurrence versus circulation type